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Sugimoto et al.

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(54) **WIRELESS COMMUNICATION DEVICE**

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(30) **Foreign Application Priority Data**

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H04W 88/06 (2009.01)
H04B 1/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04W 88/06*** (2013.01); ***H04B 1/0064*** (2013.01); ***H04W 52/0238*** (2013.01);
(Continued)

(58) **Field of Classification Search**
None
See application file for complete search history.

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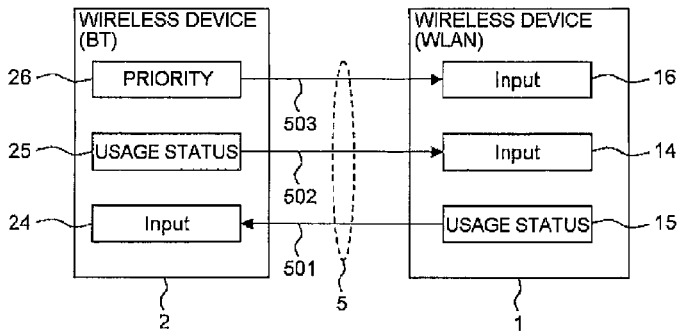
(74) *Attorney, Agent, or Firm* — Mattingly & Malur, PC

(57) **ABSTRACT**

In a wireless communication device for performing plural wireless communications with different standards using the same frequency band, degradation of communication quality and communication speed due to communication interference is prevented, while drop in throughput and occurrence of frame loss are prevented. A first wireless communication section first performs wireless communication using a first frequency band and a second wireless communication section performs second wireless communication using a second frequency band with which at least a part of the first frequency band overlaps. The first wireless communication section analyzes a communication status signal which represents a signal pattern corresponding to communication status of the second wireless communication and then determines whether it is synchronous communication, and if it is, the first wireless communication section transmits/receives data in a non-communication period when communication in the synchronous communication is not performed, in synchronization with timing of the synchronous communication.

10 Claims, 9 Drawing Sheets



(51) **Int. Cl.**

H04W 52/02	(2009.01)
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H04W 72/02	(2009.01)
H04W 72/04	(2009.01)
H04W 28/04	(2009.01)
H04W 56/00	(2009.01)
H04W 4/00	(2009.01)
H04W 84/12	(2009.01)

(52) **U.S. Cl.**

CPC ***H04W 72/1215*** (2013.01); *H04W 4/008* (2013.01); *H04W 28/04* (2013.01); *H04W 28/048* (2013.01); *H04W 56/00* (2013.01); *H04W 56/001* (2013.01); *H04W 72/02* (2013.01); *H04W 72/0446* (2013.01); *H04W 84/12* (2013.01); *Y02B 60/50* (2013.01)

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FIG. 1

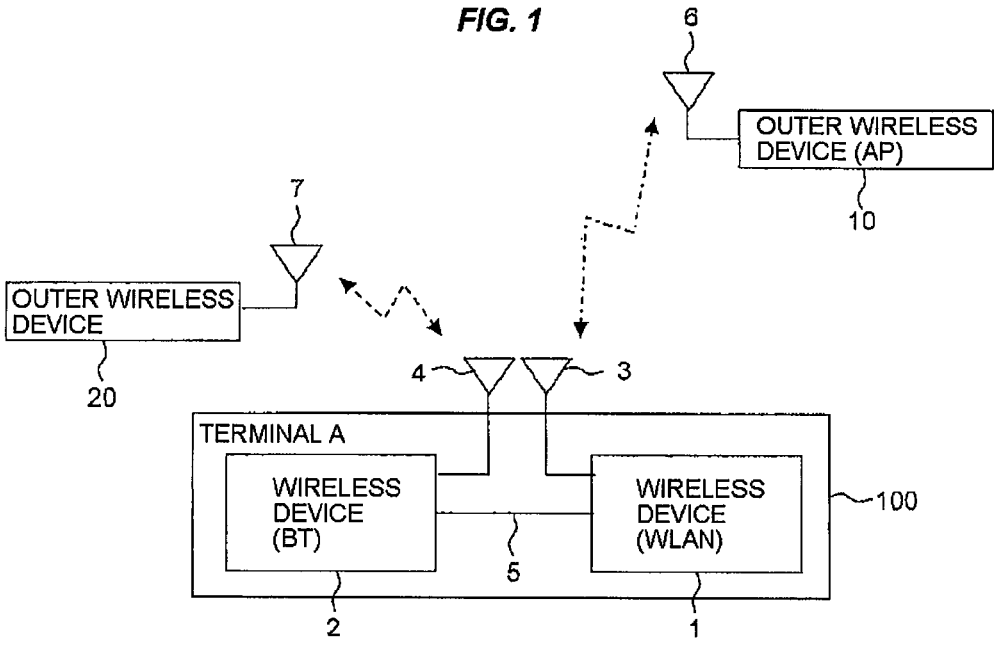

6
OUTER WIRELESS DEVICE (AP)
10
7
OUTER WIRELESS DEVICE
20
4
3
TERMINAL A
WIRELESS DEVICE (BT)
WIRELESS DEVICE (WLAN)
100
5
2
1

FIG. 2

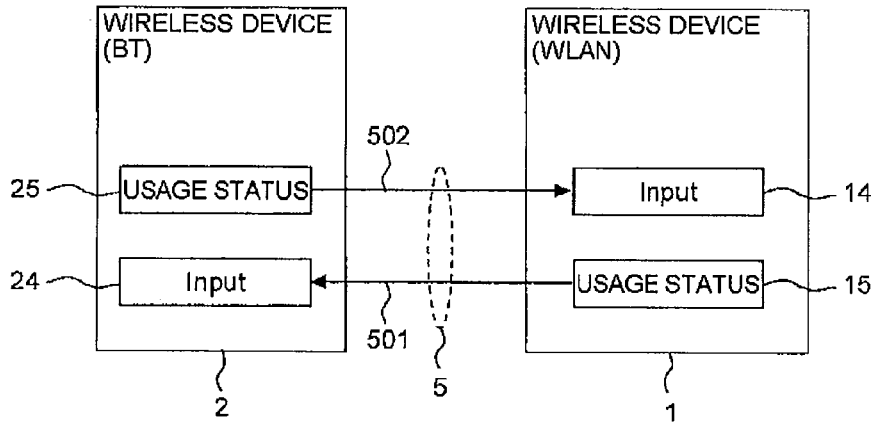

WIRELESS DEVICE (BT)
WIRELESS DEVICE (WLAN)
502
25
USAGE STATUS
Input
14
24
Input
USAGE STATUS
15
501
5
2
1

FIG. 3

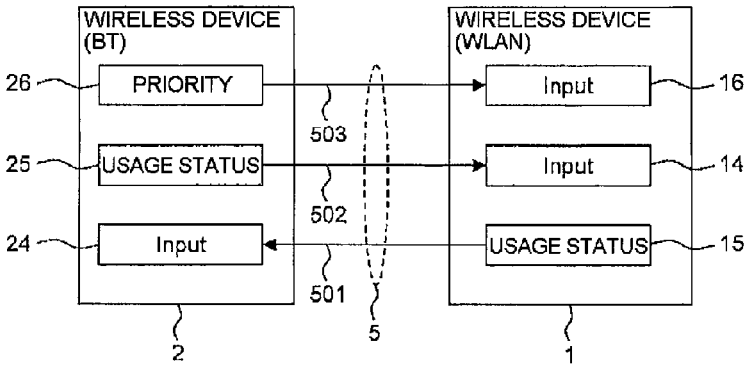

WIRELESS DEVICE (BT)
WIRELESS DEVICE (WLAN)
26
PRIORITY
Input
16
503
25
USAGE STATUS
Input
14
502
24
Input
USAGE STATUS
15
501
5
2
1

FIG. 4

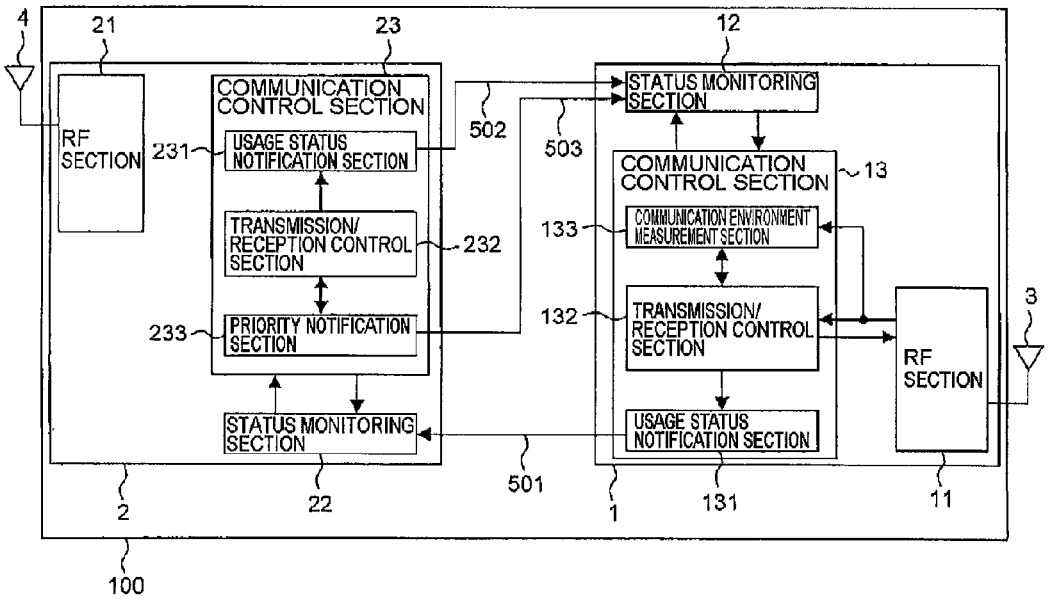

4
21
23
12
RF SECTION
COMMUNICATION CONTROL SECTION
231
USAGE STATUS NOTIFICATION SECTION
502
503
STATUS MONITORING SECTION
COMMUNICATION CONTROL SECTION
13
TRANSMISSION/ RECEPTION CONTROL SECTION
232
133
COMMUNICATION ENVIRONMENT MEASUREMENT SECTION
233
PRIORITY NOTIFICATION SECTION
132
TRANSMISSION/ RECEPTION CONTROL SECTION
3
RF SECTION
STATUS MONITORING SECTION
USAGE STATUS NOTIFICATION SECTION
501
2
22
1
131
11
100

FIG. 5

COMMUNICATION ENVIRONMENT	OUTLINE
SHORT DISTANCE	BEST ENVIRONMENT FOR RECEPTION SENSITIVITY AND COMMUNICATION QUALITY
LONG DISTANCE	POOR ENVIRONMENT FOR RECEPTION SENSITIVITY AND COMMUNICATION QUALITY

FIG. 6

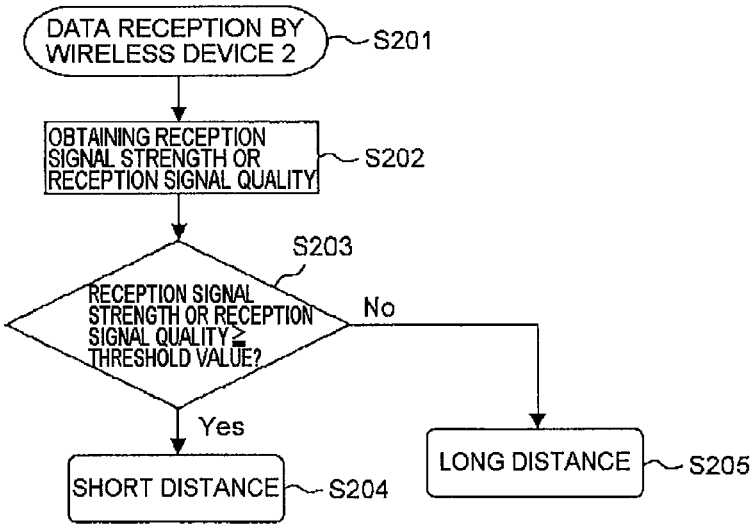


FIG. 7

COMMUNICATION STATUS	OUTLINE
UNUSED	NO COMMUNICATION IS GENERATED IN WIRELESS DEVICE 1
CONGESTED	COMMUNICATION IS CONGESTED IN WIRELESS DEVICE 1
SYNCHRONOUS COMMUNICATION	SYNCHRONOUS COMMUNICATION IS PERFORMED IN WIRELESS DEVICE 1
ASYNCHRONOUS COMMUNICATION	ASYNCHRONOUS COMMUNICATION IS PERFORMED IN WIRELESS DEVICE 1

FIG. 8

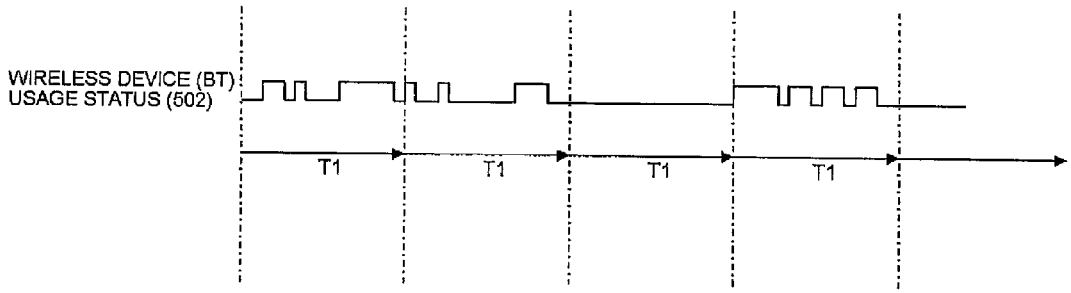


FIG. 9

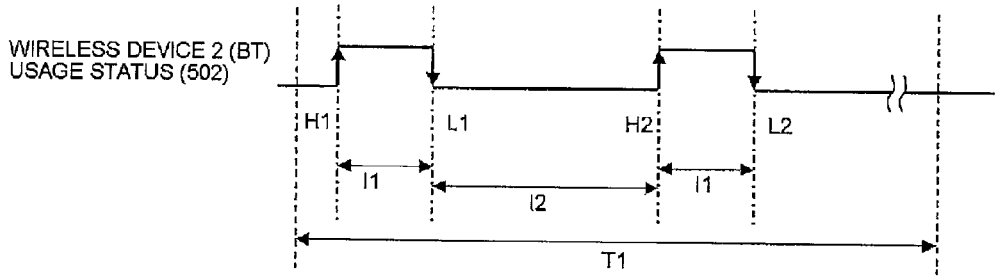


FIG. 10

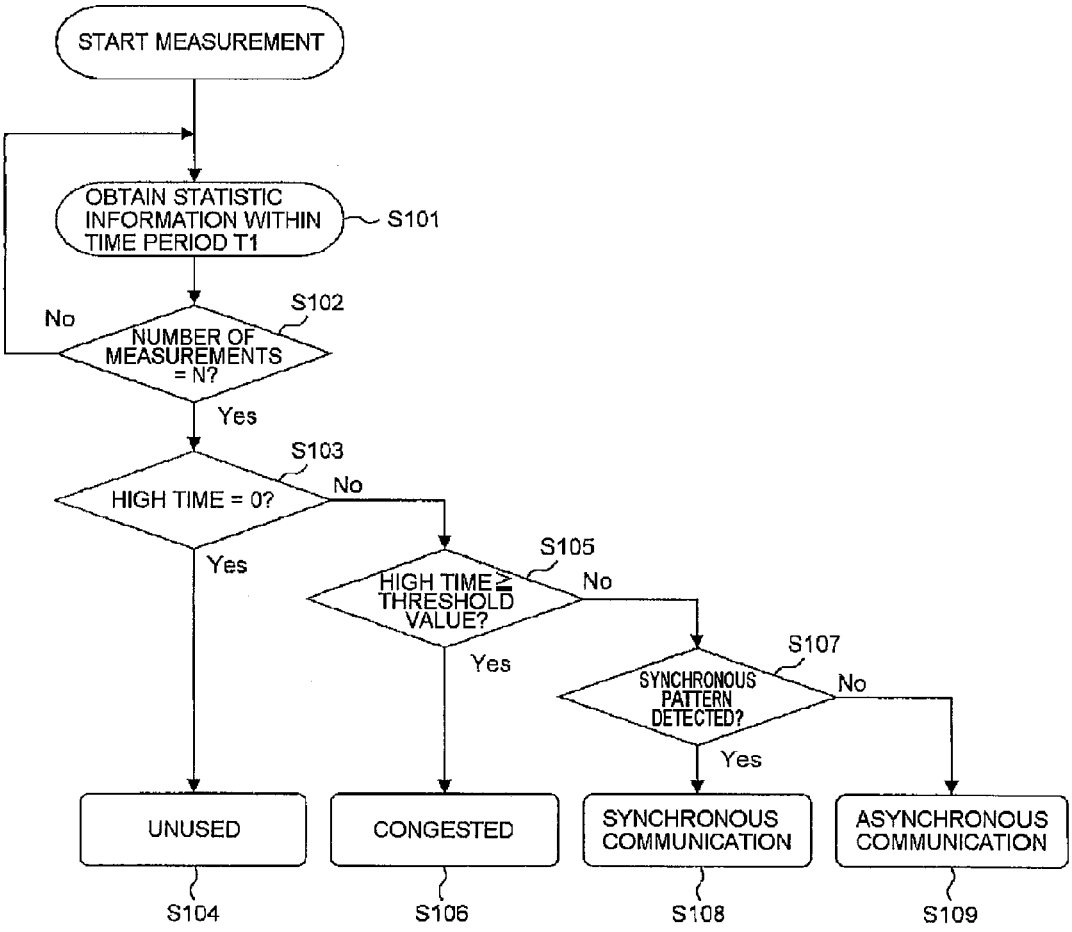

START MEASUREMENT
OBTAIN STATISTIC INFORMATION WITHIN TIME PERIOD T1
S101
S102
No
NUMBER OF MEASUREMENTS = N?
Yes
S103
HIGH TIME = 0?
No
Yes
S105
HIGH TIME ≥ THRESHOLD VALUE?
No
Yes
S107
SYNCHRONOUS PATTERN DETECTED?
No
Yes
UNUSED
CONGESTED
SYNCHRONOUS COMMUNICATION
ASYNCHRONOUS COMMUNICATION
S104
S106
S108
S109

FIG. 11

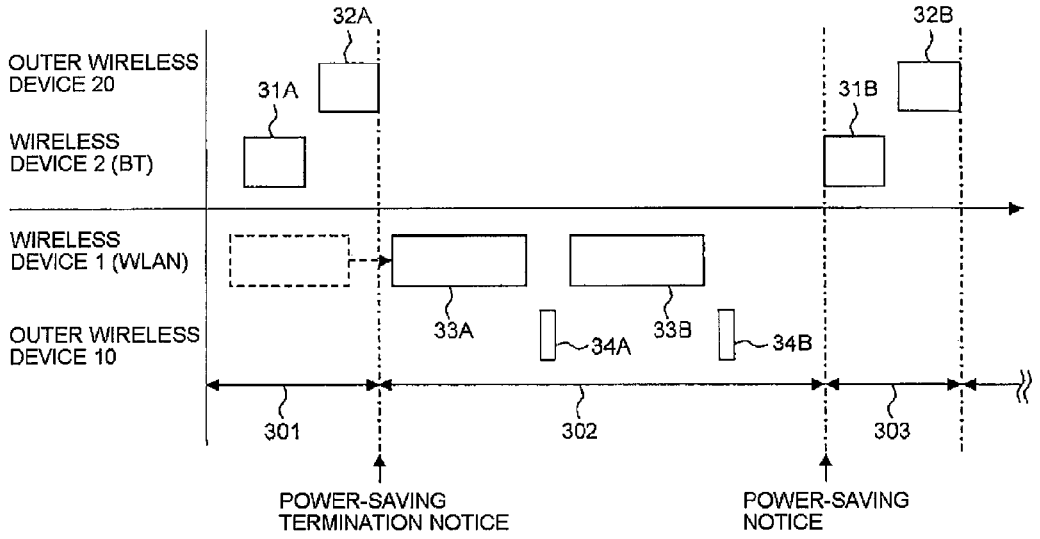

32A
32B
OUTER WIRELESS DEVICE 20
31A
31B
WIRELESS DEVICE 2 (BT)
WIRELESS DEVICE 1 (WLAN)
33A
34A
33B
34B
OUTER WIRELESS DEVICE 10
301
302
303
POWER-SAVING TERMINATION NOTICE
POWER-SAVING NOTICE

FIG. 12

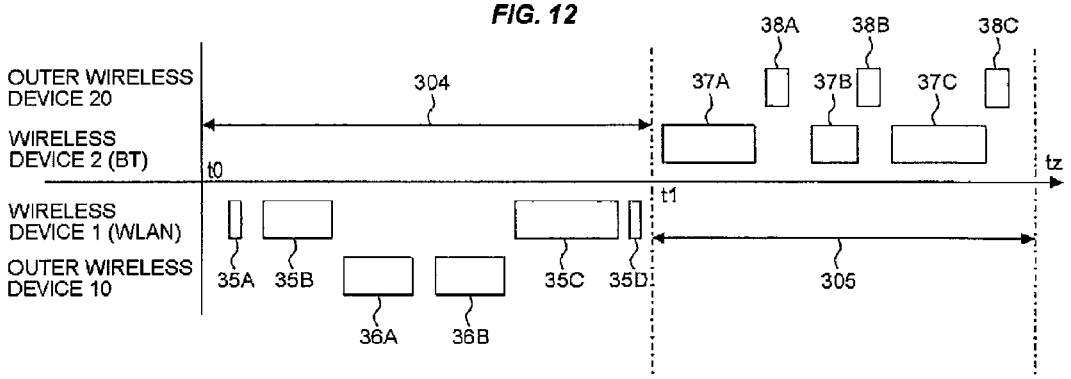

38A
38B
38C
OUTER WIRELESS DEVICE 20
304
37A
37B
37C
WIRELESS DEVICE 2 (BT)
t0
tz
t1
WIRELESS DEVICE 1 (WLAN)
OUTER WIRELESS DEVICE 10
35A
35B
35C
35D
305
36A
36B

FIG. 13

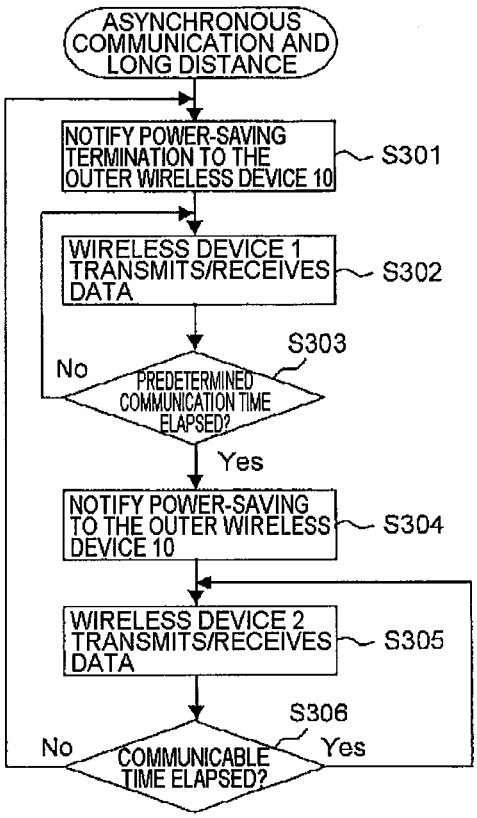

ASYNCHRONOUS COMMUNICATION AND LONG DISTANCE
NOTIFY POWER-SAVING TERMINATION TO THE OUTER WIRELESS DEVICE 10
S301
WIRELESS DEVICE 1 TRANSMITS/RECEIVES DATA
S302
S303
No
PREDETERMINED COMMUNICATION TIME ELAPSED?
Yes
NOTIFY POWER-SAVING TO THE OUTER WIRELESS DEVICE 10
S304
WIRELESS DEVICE 2 TRANSMITS/RECEIVES DATA
S305
S306
No
COMMUNICABLE TIME ELAPSED?
Yes

FIG. 14

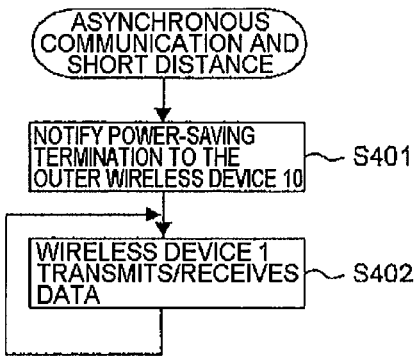
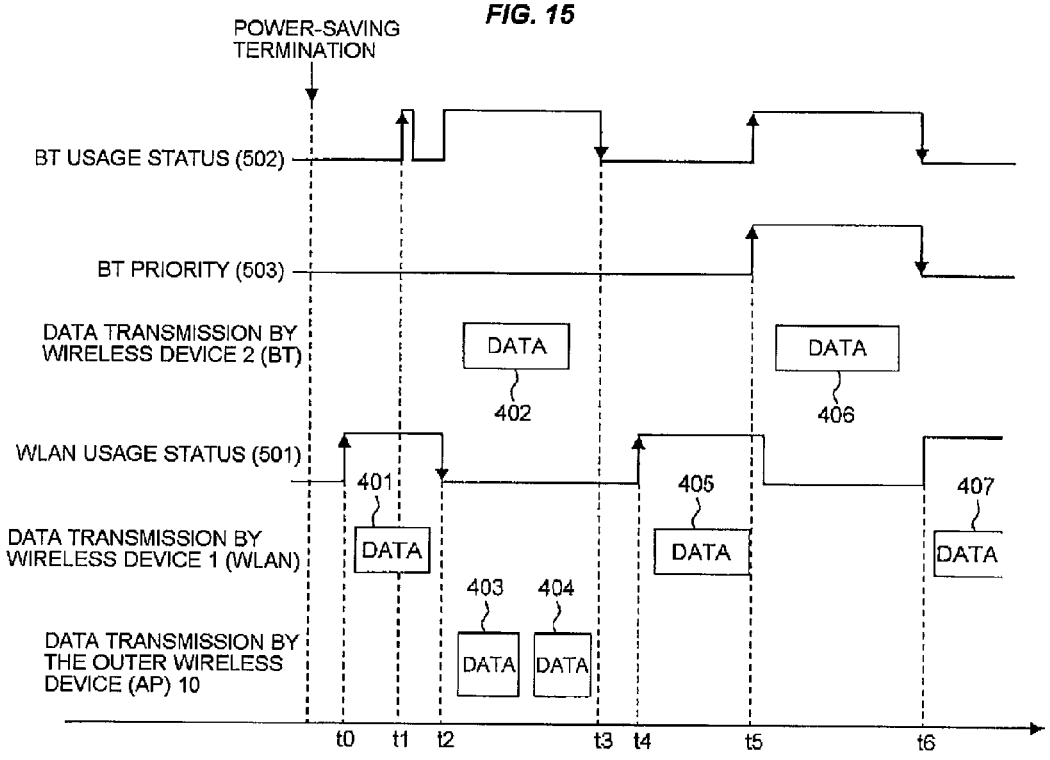

ASYNCHRONOUS COMMUNICATION AND SHORT DISTANCE
NOTIFY POWER-SAVING TERMINATION TO THE OUTER WIRELESS DEVICE 10
S401
WIRELESS DEVICE 1 TRANSMITS/RECEIVES DATA
S402

FIG. 15


POWER-SAVING TERMINATION
BT USAGE STATUS (502)
BT PRIORITY (503)
DATA TRANSMISSION BY WIRELESS DEVICE 2 (BT)
DATA
402
DATA
406
WLAN USAGE STATUS (501)
401
405
407
DATA TRANSMISSION BY WIRELESS DEVICE 1 (WLAN)
DATA
DATA
DATA
403
404
DATA TRANSMISSION BY THE OUTER WIRELESS DEVICE (AP) 10
DATA
DATA
t0
t1
t2
t3
t4
t5
t6

WIRELESS COMMUNICATION DEVICE

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. patent application Ser. No. 13/363,424, filed Feb. 1, 2012, which claims priority to Japanese Patent Application No. 2011-21607 filed on Feb. 3, 2011. The entire disclosures of these applications are incorporated herein by reference.

BACKGROUND

The present invention relates to a wireless communication device, and particularly relates to a technology that is effective when applied to a wireless communication device capable of performing a plurality of wireless communications with different standards.

Conventionally, for a plurality of wireless communications with different standards for which the same frequency band is used, there are following methods as technologies for preventing degradation of communication quality and communication speed caused by communication contention or interference. First, examples of method of physical avoidance include a method (Frequency Division Multiplex (FDM)) that uses different channels by dividing a frequency band, and a method (Code Division Multiplex (CDM)) that multiplexes communications by assigning different spread codes for the same frequency and the same time. Second, examples of method of probabilistic and dynamic avoidance include a frequency hopping method (Adaptive Frequency Hopping (AFH)) in the same frequency band, and a method that performs transmission control by means of carrier sense (Clear Channel Assessment (CCA)) before wireless communication.

Other effective methods include a method of avoiding power interference by setting an adequate distance between antennas for the respective wireless communications. However, recent downsizing of communication terminals often causes difficulty in adequately separating antennas from each other in a communication terminal. Even if the frequency bands of the wireless communications are separated adequately from each other, it is sometimes impossible to maintain communication quality or communication speed because of the power interference between antennas in a short distance. Particularly, in an audio source receiving device or the like that receives data, such as audio and music, quality is significantly degraded, depending on the communication status of another wireless device. It is more likely that conversing stably or listening to music becomes difficult. In this situation, for example, Japanese Patent Laid-Open No. 2001-217853 (Patent Document 1) discloses a method of avoiding interference between communications with different standards.

With a single communication device capable of performing communications by an IEEE802.11 wireless system and a Bluetooth (registered trademark, the same hereinafter) wireless system, the technology described in Patent Document 1 performs, by time division, data transmission by the IEEE802.11 wireless system and data transmission by the Bluetooth wireless system.

SUMMARY

However, when communications are performed uniformly by time division as in Patent Document 1, although communication interference can be prevented, problems are caused,

such as a drop in throughput. Further, as a result of the inventors' consideration of a different method of preventing interference, in a case of adopting a communication control method that always prioritizes wireless communication which requires a high quality of data, such as audio or music, frame loss or the like caused by communication interference can be prevented. However, when communication is requested by a wireless communication side which requires high quality, the other wireless communication side is forced to interrupt communication, and thus frame loss occurs in the other wireless communication, resulting in degradation of the communication quality and the like of the other wireless communication.

The present invention has been made in view of the above circumstances and provides a wireless communication device for performing a plurality of wireless communications with different standards to prevent degradation in communication quality and communication speed due to communication interference, while preventing drop in throughput and occurrence of frame loss.

The other purposes and the new feature of the present invention will become clear from the description of the present specification and the accompanying drawings.

The following explains briefly the outline of a typical invention of the invention among the inventions disclosed in the present application.

A wireless communication device includes a first wireless communication section for performing first wireless communication using a first frequency band; and a second wireless communication section for performing second wireless communication using a second frequency band. The first wireless communication section analyzes a communication status signal that is output by the second wireless communication section and that represents a signal pattern corresponding to a communication status of the second wireless communication and then determines whether or not the second wireless communication is synchronous. If the second wireless communication is determined to be synchronous, the first wireless communication section performs data transmission/reception in a non-communication period when no synchronous communication is performed, in synchronization with the synchronous communication timing.

The following explains briefly the effect acquired by the typical invention among the inventions disclosed in the present application.

In a plurality of wireless communications with different standards, the present wireless communication device can prevent degradation in communication quality and communication speed due to communication interference, while preventing drop in throughput and occurrence of frame loss.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an outline of a wireless communication terminal in a first embodiment.

FIG. **2** shows a method of connecting a wireless device **1** and a wireless device **2** (via two lines).

FIG. **3** shows a method of connecting a wireless device **1** and a wireless device **2** via three lines.

FIG. **4** is a block diagram showing an inner configuration of a wireless communication terminal **100**.

FIG. **5** shows a WLAN communication environment.

FIG. **6** is a flowchart showing a determination process of the WLAN communication environment.

FIG. **7** is a diagram showing a status of BT communication by the wireless device **2**.

FIG. **8** shows a communication status signal **502** that is output from the wireless device **2**.

FIG. **9** shows a signal pattern of synchronous communication.

FIG. **10** is a flowchart showing a determination process of the communication status of the wireless device **2**.

FIG. **11** shows a method of adjusting the data transmission timing of the wireless device **1**.

FIG. **12** shows data transmission timing in communications by the wireless device **1** and the wireless device **2** by time division.

FIG. **13** is a flowchart showing a control method for performing the communications by the wireless device **1** and the wireless device **2** by time division.

FIG. **14** is a flowchart showing a communication control method that corresponds to the communication status and the priority of the wireless device **2**.

FIG. **15** shows data transmission timing under communication control that corresponds to the communication status and the priority of the wireless device **2**.

DETAILED DESCRIPTION

1. Outline of the Embodiment

First, the outline of typical embodiments according to the invention disclosed by the present application will be described below. Reference numerals in the drawings, which are attached with parentheses and will be referred to in the description of the outline of the typical embodiment, represent only examples that are included in the concepts of the configuration elements attached with the reference numerals.

[1] (Wireless Communication Device that Determines a Communication Pattern (Synchronization) to Control Communication)

A wireless communication device (**100**) according to a typical embodiment of the invention includes a first wireless communication section (1) for performing first wireless communication (WLAN communication) using a first frequency band and a second wireless communication section (2) for performing second wireless communication (BT communication) using a second frequency band. The second wireless communication section transmits/receives data by the second wireless communication and outputs a communication status signal (**502**) that represents a signal pattern corresponding to a status of the second wireless communication. The first wireless communication section analyzes the signal pattern of the communication status signal and then determines whether or not the second wireless communication is synchronous. If the second wireless communication is determined to be synchronous, the first wireless communication section transmit/receive data in a non-communication period (**302**) when the synchronous communication is not performed, in synchronization with the synchronous communication timing.

For communication of audio data, such as music and audio conversation, which requires a higher communication quality, a synchronous communication method is mostly adopted. In this situation, the wireless communication device of the above item 1 determines whether or not the second wireless communication is synchronous. If it is synchronous communication, the first wireless communication section synchronizes with the second wireless communication and then performs wireless communication in a non-communication period of the synchronous communication. Thus, it is possible to prevent power interference between the first wireless communication and the second wireless communication, and to prevent frame loss and the like due to the interference. Further, analyzing the pattern of the communication status signal that is output by the second wireless communication device enables easy determination whether or not the second wireless communication is synchronous, and synchronization with the timing of the second wireless communication. Still further, in a method that performs the first wireless communication and the second wireless communication uniformly by time division, it is impossible to perform the first wireless communication even when the second wireless communication is not performed in a period assigned as a period for the second wireless communication. On the other hand, the wireless communication device of item 1 detects and synchronizes with the timing of the synchronous communication by the second wireless communication, assigns a non-communication period as a period when the first wireless communication is possible. Thus, it is possible to prevent drop in throughput, compared with performing communication uniformly by time division.

[2] (Determining a Communication Pattern (Asynchronous) to Control Communication)

In the wireless communication device of the above item 1, the first wireless communication section analyzes the pattern of the communication status signal and then determines whether or not the second wireless communication is asynchronous. If it is determined to be asynchronous, the first wireless communication section determines a data transmission/reception mode, corresponding to the communication environment between the first wireless communication section and a first outer wireless device (**10**) that is the object of the first wireless communication section.

When one wireless communication is performed in a short distance and another wireless communication is performed in a long distance, the power interference effect becomes larger because the attenuation of reception power is large in the communication performed in the long distance. In contrast, when another wireless communication is performed in the short distance, the power interference effect tends to be small even if power interference is received, because the attenuation of reception power is small. A wireless communication device of the above item 2 determines the communication environment between the first wireless communication section and the first outer wireless device and then can select a data transmission/reception mode suitable for the communication environment.

[3] (Determination of Communication Environment)

In the wireless communication device of item 2, the first wireless communication section measures the reception signal strength or the reception signal quality of the first wireless communication. If the measured reception signal strength or the measured reception signal quality is higher than a predetermined threshold value, the first wireless communication section determines that the communication environment is good. Otherwise it determines that the environment is poor.

It is possible to easily determine whether the communication environment is good or poor.

[4] (Communication Control Corresponding to Communication Environment during Asynchronous Communication)

In the wireless communication device of item 3, the first wireless communication section asserts a notification signal (**501**) when performing the first wireless communication. The second wireless communication section stops the second wireless communication if the notification signal is asserted. Further, when the second wireless communication is determined to be asynchronous, the first wireless communication section, if determining that the communication environment is poor, controls the notification signal to perform the first wireless communication and the second wireless communi-

cation by time division. The first wireless communication section, if determining that the communication environment is good, transmits data when the second wireless communication is not performed.

When the communication environment is poor, such as when the first wireless communication is performed in a long distance, frame loss can be reduced by performing the first wireless communication and the second wireless communication by time division to avoid the effects of interference between the communications. Further, when the communication environment is good, such as when the first wireless communication is performed in a short distance, because the power interference effect tends to be small, it is possible to perform communication for which drop in throughput is prevented, by a method of communication that corresponds to the mutual communication statuses, instead of a method of communication by time division.

[5] (Stopping Transmission from AP during Synchronous Communication by BT)

In the wireless communication device of any one of items 1 to 4, when the second wireless communication is determined to be synchronous, the first wireless communication section further instructs to stop data transmission from the first outer wireless device in a communication period of the synchronous communication.

As described above, in the wireless communication device of any one of items 1 to 4, when the second wireless communication is synchronous, the first wireless communication section transmits data during non-communication periods of the synchronous communication. However, even when data transmission from the first wireless communication section is stopped during the second wireless communication, data may be transmitted from the first outer wireless device and then the second wireless communication may be affected. In this situation, when the second wireless communication is performed as synchronous communication, communication interference can be prevented by stopping not only data transmission from the first wireless communication section but also data transmission from the first outer wireless device.

[6] (Stopping Transmission from AP during BT Asynchronous Communication and in Poor Communication Environment)

Further, in the wireless communication device of any one of items 2 to 5, if the second wireless communication is determined to be asynchronous and moreover the communication environment is determined to be poor, the first wireless communication section further instructs to stop data transmission from the first outer wireless device when the second wireless communication is performed.

As described above, the first outer wireless device may transmit data even during the second wireless communication. In this case, if the communication environment for the first wireless communication is poor, the first wireless communication section may be able to receive no data transmitted from the first outer wireless device. In this situation, it is possible to reduce frame loss of the data transmitted from the first outer wireless device, by limiting data transmission from the first outer wireless device in poor communication environment of the first outer wireless communication.

[7] (Transmission Control by a Sleep Signal)

In the wireless communication device of item 5 or 6, the instruction to stop the data transmission is carried out by transmitting, to the first outer wireless device, a sleep signal (power-saving notice) that represents the transition of the first wireless communication section into a power-saving state.

It is possible to easily stop data transmission from the first outer wireless device. When the first wireless communication is performed by a wireless system that is compliant to the IEEE 802.11 standard, it is only required to use an existing protocol (power-saving notification function), and it is unnecessary to prepare a new protocol to instruct to stop the data transmission.

[8] (Priority Signal)

In the wireless communication device of any one of items 3 to 7, the second wireless communication section further outputs a priority signal (**503**) representing that the second wireless communication is performed prior to the first wireless communication. When the second wireless communication is determined to be asynchronous and the communication environment is determined to be good, the first wireless communication section transmits no data when the priority signal is asserted.

In a state that communication is controlled corresponding to each of the communication statuses, even when the second wireless communication and the first wireless communication conflict with each other, the second wireless communication can be performed preferentially.

[9] (Determining a Communication Pattern (Congested State) to Control Communication)

In the wireless communication device of any one of items 2 to 8, before determining whether the communication is synchronous or asynchronous, the first wireless communication section determines whether or not the second wireless communication is in a congested state. If it is in the congested state, the first wireless communication section stops data transmission/reception.

[10] (Determining a Communication Pattern (Unused State) to Control Communication)

In the wireless communication device of any one of items 1 to 9, the first wireless communication section determines whether or not the second wireless communication is performed. If it is not performed, the first wireless communication section transmits/receives data at desired timing.

In a state that the second wireless communication is not performed, the first wireless communication section can transmit/receive data at desired timing. Throughput does not drop, compared to a method that performs communication at timings uniformly assigned by time division.

[11] (Method of Determining Signal Pattern)

In the wireless communication device of item 10, the communication status signal is a digital signal that is set to a first value during communication and is set to a second value during non-communication. Further, when the communication status signal has not become the first value in a predetermined time, the first wireless communication section determines that the second wireless communication is not performed. In the predetermined time, when the total time when the communication status signal has been the first value is a predetermined time or more, the first wireless communication section determines that the second wireless communication is in a congested state. When the same signal pattern based on a time when the communication status signal is the first value and a time when the communication status signal is the second value is detected plural times in the predetermined time, the first wireless communication section determines that the second wireless communication is synchronous. In the other cases, the first wireless communication section determines that the second wireless communication is asynchronous.

It is possible to easily determine the status of the second wireless communication.

[12] (Wireless Communication Device (Independent) that Stops Transmission from AP During BT Communication)

A wireless communication device (**100**) in another typical embodiment according to the invention performs first wireless communication (WLAN communication) that uses a first frequency band, and second wireless communication (BT communication) that uses a second frequency band with which at least a part of the first frequency band overlaps. When performing the second wireless communication, the wireless communication device instructs to stop data transmission from an outer wireless device (**10**) that is the object of the first wireless communication.

As described above, communication is limited in a state that frame loss of transmission data from the first outer wireless device tends to occur. Accordingly, it is possible to reduce frame loss of transmission data from the first outer wireless device, due to the interference from the second wireless communication. Also, it is possible to prevent interference by data transmission from the first outer wireless device on the second wireless communication.

[13] (Transmission Control by Sleep Signal)

In the wireless communication device of item 12, the instruction to stop the data transmission is performed by transmitting, to the outer wireless device, a sleep signal (power-saving notice) that represents transition into a power-saving state.

As with item 7, it is possible to easily stop data transmission from the first outer wireless device.

[14] (Wireless Communication Device (Independent) that Determines Communication Pattern to Control Communication)

A wireless communication device (**100**) in another typical embodiment according to the invention includes a first wireless communication section (1) for performing first wireless communication (WLAN communication) that uses a first frequency band; and a second wireless communication section (2) for performing second wireless communication (BT communication) that uses a second frequency band with which at least a part of the first frequency band overlaps. The second wireless communication section transmits/receives data by the second wireless communication, and outputs a communication status signal (**502**) that is set to a first value during communication and is set to a second value during non-communication. Further, the first wireless communication section analyzes a pattern of the communication status signal in a predetermined time. When the communication status signal has not become the first value in the predetermined time, the first wireless communication section determines that the second wireless communication is not performed. In the predetermined time, the total time when the communication status signal has been the first value is a predetermined time or more, the first wireless communication section determines that the second wireless communication is in a congested state. When the same signal pattern based on a time when the communication status signal has been the first value and a time when the communication status signal has been the second value, has been detected plural times during the predetermined time, the first wireless communication section determines that the second wireless communication is synchronous. In the other cases, the first wireless communication section determines that the second wireless communication is asynchronous and determines an operation mode of data transmission/reception, in accordance with the determination result.

It is possible to easily determine the status of the second wireless communication and the operation mode of data transmission/reception in the first wireless communication.

[15] (Determination on Communication Environment)

In the wireless communication device of item 14, when determining that the second wireless communication is asynchronous, the first wireless communication section measures the reception signal strength or the reception signal quality of the first wireless communication. If the measured reception signal strength or the measured reception signal quality of the first wireless communication is higher than a predetermined threshold value, the first wireless communication section determines that the communication environment is good. If not, the first wireless communication section determines that it is poor.

It is possible to easily determine whether the communication environment is good or poor and to easily change the operation mode, in accordance with the communication environment.

[16] (Resuming Data Transmission from AP Upon Notification of Power-Saving Termination)

In the wireless communication device of any one of items 7 to 11, the first wireless communication section starts communication, by transmitting to the first outer wireless device a signal that notifies power-saving termination.

It is possible to easily resume communication from the first outer wireless device to the wireless communication device.

[17] (Resuming Data Transmission from AP Upon Request for Frame Acquisition)

In the wireless communication device of any one of items 7 to 11, the first wireless communication section starts communication, by transmitting to the first outer wireless device a signal to request frame acquisition.

It is possible to easily resume communication from the first outer wireless device to the wireless communication device.

[18] (Second Frequency Band with which at Least a Part of First Frequency Band Overlaps)

A wireless communication device (**100**) in another typical embodiment according to the invention includes a first wireless communication section for performing first wireless communication that uses a first frequency band; and a second wireless communication section for performing second wireless communication that uses a second frequency band with which at least a part of the first frequency band overlaps. The second wireless communication section transmits/receives data by the second wireless communication, and outputs a communication status signal (**502**) that represents a signal pattern corresponding to the status of the second wireless communication. The first wireless communication section analyzes the signal pattern of the communication status signal and then determines whether or not the second wireless communication is synchronous. When a determination result is synchronous communication, the first wireless communication section transmits/receives data in a non-communication period (**302**) when communication in the synchronous communication is not performed, in synchronization with communication timing of the synchronous communication.

As with item 1, it is possible to prevent power interference between the first wireless communication and the second wireless communication and then to prevent occurrence of frame loss and the like due to interference. Further, it is possible to easily determine whether or not the second wireless communication is synchronous, and further to synchronize the first wireless communication with the timing of the second wireless communication. Further, by the wireless communication device of item 18, as with item 1, it is possible to prevent drop in throughput, compared with performing communication uniformly by time division.

2. Detailed Description of Preferred Embodiments

Preferred embodiments will be described below in further details.

Embodiment 1

FIG. **1** is an outline of a wireless communication terminal in Embodiment 1.

A wireless communication **100** (hereinafter, referred to merely as 'terminal') shown in the figure is a portable terminal, such as a mobile phone or a smart phone for performing first wireless communication that uses a predetermined frequency band and second wireless communication that uses a predetermined frequency band. The frequency bands used by the first wireless communication and the second wireless communication may differ from each other, may be close to each other, and may be overlapping with each other at least partially. The following is described with an assumption that the first wireless communication (hereinafter, also referred to as 'WLAN communication') complies with the IEEE 802.11 standard using the 2.4-GHz band, and the second wireless communication (hereinafter, also referred to as 'Bluetooth (BT) communication') complies with the IEEE 802.15 standard using the 2.4-GHz band.

The terminal **100** has a wireless device **1** and a wireless device **2**. The wireless device **1** performs WLAN communication via an antenna **3** with a outer wireless device (Access Point (AP)) **10** that is installed within a communicable range. On the other hand, the wireless device **2** performs BT communication via an antenna **4** with a outer wireless device **20** that is installed within a communicable range. The outer wireless device **20** may be a wireless head phone.

The wireless device **1** and the wireless device **2** are adjacent to each other in the terminal **100**, and are connected with each other by a signal line **5**. Methods of connecting the wireless devices **1** and **2** include a two-line control method, which connects the devices by two signal lines, and a three-line control method, which connects the devices by three signal lines.

FIGS. **2** and **3** show methods of connecting the wireless device **1** and the wireless device **2**.

FIG. **2** shows a connection between the wireless device **1** and the wireless device **2** by two signal lines. FIG. **3** shows a connection between the wireless device **1** and the wireless device **2** by three signal lines.

When the wireless devices are connected by two signal lines, as shown in FIG. **2**, an output port **15** of the wireless device **1** and an input port **24** of the wireless device **2** are connected by a signal line **501**. A signal (hereinafter, referred to as 'communication status signal **501**') representing the status of the WLAN communication by the wireless device **1** is output to the signal line **501**. Further, an output port **25** of the wireless device **2** and an input port **14** of the wireless device **1** are connected by a signal line **502**, and a signal (hereinafter referred to as 'communication status signal **502**') representing the status of the BT communication by the wireless device **2** is output to the signal line **502**. These connections allow the wireless device **1** and the wireless device **2** to recognize the mutual communication statuses.

When the wireless devices are connected by three signal lines, as shown in FIG. **3**, in addition to the connections by the above-mentioned signal lines **501** and **502**, an output port **26** of the wireless device **2** and an input port **16** of the wireless device **1** are connected by a signal line **503**. A signal (hereinafter referred to as 'priority signal **503**') representing the priority of the BT communication by the wireless device **2** is output to the signal line **503**. The priority signal **503** is a digital signal representing a low priority or a high priority, and is used by the priority control to be described. In the following description, the terminal **100** will be described with an assumption that the wireless device **1** and the wireless device **2** are connected by a three-line control method in the terminal **100**.

FIG. **4** is a block diagram showing an inner configuration of the terminal **100**.

The wireless communication **1** (WLAN) has a status monitoring section **12**, a communication control section **13**, and an RF section **11**. The status monitoring section **12** and the communication control section **13** are functional sections that are implemented by a microprocessor for executing processes by programs and implemented by LSI for baseband processing.

The status monitoring section **12** receives a priority signal **503** output to the signal line **503** and a communication status signal **502** output to the signal line **502**, which are output from the wireless device **2**, determines, based on the input signals, the communication status of the wireless device **2**, and provides the communication control section **13** with a determination result. The determination method is described later in detail.

The communication control section **13** includes, for example, a transmission/reception control section **132**, a usage status notification section **131**, and a communication environment measurement section **133**. Controlled by the transmission/reception control section **132**, the usage status notification section **131** outputs a communication status signal **501** representing the status of WLAN communication performed by the wireless device **1**. The communication status signal **501** is a digital signal. The signal is set high (High) when the wireless device **1** is performing WLAN communication and is set low (Low) when it is not.

The communication environment measurement section **133** measures the reception signal strength or the reception signal quality for each frame received via the antenna **3**, and based on the measured reception signal strength or measured reception signal quality, determines the WLAN communication environment. In this method, the communication environment measurement section **133** monitors the communication environment between the wireless device **1** and the outer wireless device **10**. A reception signal strength is an index representing the magnitude of a reception signal including noise. If a frame signal expected to be received is strong, the signal can be received even when it includes noise. Further, even when only noise is included, the reception signal strength becomes high. Not only noise but also an interference signal causes the same. A reception signal quality is an index representing the signal quality of a desired frame, and is expressed by the ratio between a frame signal expected to be received and a noise signal (SNR: Signal to Noise Ratio). Even when a frame signal is weak, the frame signal can be received if noise also is weak. Not only an SNR but also an SIR (Signal to Interference Ratio), a D/U ratio, or the like is used.

FIG. **5** shows determination kinds of the WLAN communication environment.

As shown in the figure, the communication environment between the wireless device **1** and the outer wireless device **10** is roughly categorized into a short distance and a long distance. Generally, the reception signal strength, the reception signal quality, or the communication quality is inversely proportional to the communication distance. The communication distance is short if the reception signal strength or the

reception signal quality is high. The communication distance is long if the reception signal strength or the reception signal quality is low.

FIG. **6** is a flowchart showing a determination process of the WLAN communication environment.

First, the communication environment measurement section **133** obtains reception data per frame via the antenna **3** from the RF section **11** (S**201**). The communication environment measurement section **133** measures the reception signal strength or the reception signal quality, based on the obtained reception data (S**202**), and then determines whether or not the measured reception signal strength or measured reception signal quality is larger than a predetermined threshold value (S**203**). If the measured reception signal strength or the measured reception signal quality is larger than the predetermined threshold value, the communication environment measurement section **133** determines that the WLAN communication environment is of a short distance (S**204**). If the measured reception signal strength or the measured reception signal quality is lower than the predetermined threshold value, the communication environment measurement section **133** determines that the WLAN communication is of a long distance (S**205**).

Based on a determination result of the communication status of the wireless device **2** by the status monitoring section **12**, and a measurement result of the communication environment by the communication environment measurement section **133**, the transmission/reception control section **132** controls data transmission/reception via the antenna **3** and the RF section **11**, and controls communication of the wireless device **2** by controlling the usage status notification section **131**. Communication control by the transmission/reception control section **132** will be described later in detail.

The RF section **11** receives a reception signal from the antenna **3**, converts the received reception signal into a signal with a frequency and amplitude processable by the communication control section **13** in the later stage, and outputs the signal. Further, the RF section **11** converts the transmission signal generated by the communication control section **13** into a signal with a frequency and amplitude transmittable by the antenna **3**, and outputs the signal. The RF section **11** may be a one-chip RFIC (Radio-Frequency Integrated Circuit), and may be configured as a one-chip system LSI including the baseband sections of the status monitoring section **12** and the communication control section **13**.

The wireless device **2** has a status monitoring section **22**, a communication control section **23**, and an RF section **21**. The status monitoring section **22** and the communication control section **23** are functional sections implemented by a microprocessor for execution of program processes, and implemented by an LSI for baseband processing.

The status monitoring section **22** receives a communication status signal **501** from the wireless device **1**, and based on the received signal, determines whether or not the wireless device **1** is in communication. When the communication status signal **501** is High, the status monitoring section **22** determines that the wireless device **1** is in communication. When the communication status signal **501** is Low, the status monitoring section **22** determines that the wireless device **1** is performing no communication. The communication control section **23** obtains a determination result.

The communication control section **23** includes a transmission/reception control section **232**, a usage status notification section **231**, and a priority notification section **233**. Controlled by the transmission/reception control section **232**, the usage status notification section **231** outputs a communication status signal **502** representing the status of BT communication by the wireless device **2**. The communication status signal **502** is output at a timing earlier (several μs earlier) than a timing of start of communication. The communication status signal **502** will be described later in detail.

Controlled by the transmission/reception control section **232**, the priority notification section **233** outputs a priority signal **503** that requests performing BT communication by the wireless device **2** in prior to WLAN communication. When the priority signal **503** is High, it indicates high priority to represent a request for high priority to BT communication. The priority signal **503** is used for communication control by priority that will be described later.

Based on a determination result by the status monitoring section **22**, the transmission/reception control section **232** controls transmission of data via the antenna **4** and the RF section **21**, controls the usage status notification section **231** and the priority notification section **233**, and then, outputs the communication status signal **502** and the priority signal **503**. The transmission/reception control section **232** performs no BT communication when the wireless device **1** is in communication. It performs BT communication at desired timing when the wireless device **1** is not in communication.

The RF section **21** receives a reception signal from the antenna **4** to the RF section **21**, converts the received reception signal into a signal with a frequency and amplitude processable by the communication control section **23**, and outputs the signal. The RF section **21** also converts a transmission signal generated by the communication control section **23** into a signal with a frequency and amplitude transmittable from the antenna **4** and outputs the signal. The RF section **21** may be a one-chip RFIC, similarly to the above-mentioned RF section **11**, and may be configured as a one-chip system LSI including the baseband section of the status monitoring section **22** and the communication control section **23**.

A method of determining the communication status of BT communication, by the status monitoring section **12** of the wireless device **1**, will be described.

FIG. **7** shows a communication status of BT communication by the wireless device **2**.

As shown in the figure, the communication status of BT communication is divided into four unused state, congested state, synchronous communication, and asynchronous communication. The unused state refers to a state in which BT communication is not performed by the wireless device **2**. The congested state refers to a state in which BT communication is frequently performed by the wireless device **2**, and communication is congested. The synchronous communication refers to a state in which synchronous communication, which is communication performed with a constant cycle and a constant time length, is performed. The asynchronous communication refers to a state in which communication, which is not synchronous communication, is performed though not so frequently as the congested state.

The above four states are determined when the status monitoring section **12** analyzes the communication status signal **502**.

FIG. **8** shows a communication status signal **502** output from the wireless device **2**.

As shown in the figure, the communication status signal **502** is output as a digital signal. A section High represents that BT communication is performed. A section Low represents that BT communication is not performed. The status monitoring section **12** obtains statistic information on changes of rising and falling of the communication status signal **502** during a predetermined time period T1, and based on the obtained statistic information, determines the communica-

tion status of the wireless device **2**. The statistic information per time T1 is measured N times (The number N is an integer of 1 or more). Further, the statistic information obtained by the status monitoring section **12** is stored in a storage area such as a memory, which is not shown. To simplify description, a concrete method of determination will be described below, assuming that the number of measurements N is 1.

For example, when neither change in rising of the communication status signal **502** nor no High section occurs during a time T1, the communication state is determined to be in the unused state. Further, in case the total time, in which the signal level is High, exceeds a predetermined threshold value during a time T1, the communication state is determined to be in the congested state. The predetermined threshold value is not particularly limited, and is a time that is 80% of the time T1.

If the communication status signal **502** is the signal pattern of synchronous communication during a time T1, the communication is determined to be synchronous. FIG. **9** shows a signal pattern of synchronous communication. As shown in the figure, the same signal pattern with a cycle (I1+I2) and a High section I1 is repeated in synchronous communication. In this situation, the status monitoring section **12** determines synchronization, based on each High section **11** of the communication status signal **502** from a rising edge to a falling edge, and each Low section **12** from the falling edge to the next rising edge. If the High sections (I1) are the same and the same signal pattern (I1+I2) is detected m (The number m is an integer of 2 or more.) times, the BT communication is determined to be synchronous.

In a case that does not correspond to any of the above-mentioned three states, the status monitoring section **12** determines the communication to be asynchronous.

FIG. **10** is a flowchart showing a determination process of the communication status of the wireless device **2**.

The status monitoring section **12** starts measuring the communication status signal **502**, and obtains the statistic information on the communication status signal **502** during a predetermined time T1 (S**101**). Then, the status monitoring section **12** determines whether or not the number of measurements has reached N (S**102**). If the number of measurements has not reached N, the signal is measured again to obtain the statistic information. If the number of measurements has reached N, the status monitoring section analyzes the obtained statistic information, and determines presence or absence of a High section during the time T1 (S**103**). If the status monitoring section **12** determines that a High section is absent, the status monitoring section **12** determines that the wireless device **2** is in the unused state (S**104**). If the status monitoring section **12** determines that the High section is present in step S**103**, the status monitoring section **12** determines whether or not the total time of High sections exceeds the predetermined threshold value (S**105**). If the total time of High sections exceeds the predetermined threshold value, the status monitoring section **12** determines that BT communication is in the congested state (S**106**). In step S**105**, if the total time of High sections does not exceed the predetermined threshold value, the status monitoring section **12** determines presence or absence of the signal pattern of synchronous communication (S**107**). If the signal pattern of synchronous communication has been detected by the above-mentioned method, the status monitoring section **12** determines that the BT communication is synchronous (S**108**). If the signal pattern of synchronous communication has not been detected, the status monitoring section **12** determines that the BT communication is asynchronous (S**109**).

The method of controlling communication by the communication control section **13** will be described below.

As has been described above, the transmission/reception control section **132** of the communication control section **13** controls data transmission/reception and the communication by the wireless device **2**, based on a determination result of the BT communication by the status monitoring section **12**. A concrete control method corresponding to the determination result of the BT communication is as follows.

(1) If Determination Result of Communication Status of Wireless Device **2** is Unused State:

If the determination result of the communication status of the wireless device **2** is the unused state, the transmission/reception control section **132** performs WLAN communication at desired timing. In this case, even if WLAN communication is performed, as the WLAN communication neither affects BT communication nor is affected by BT communication, the wireless device **2** performs communication at desired timing.

(2) If Determination Result of Communication Status of Wireless Device **2** is Congested State:

If the determination result of the communication status of the wireless device **2** is the congested state, the transmission/reception control section **132** performs no WLAN communication. If the communication status of the wireless device **2** is the congested state, it is in a state requiring that BT communication occupies the communication. In this state, if control is performed to perform WLAN communication and BT communication by time division, the throughput of BT communication drops, which is inappropriate. Accordingly, the transmission/reception control section **132** performs no WLAN communication until the congested state of BT communication is resolved.

(3) If Determination Result of Communication Status of Wireless Device **2** is Synchronous Communication:

If the determination result of the communication status of the wireless device **2** is synchronous communication, to perform WLAN communication in non-communication periods during the synchronous communication of BT communication, the transmission/reception control section **132** adjusts timing of data transmission from the wireless device **1**, and also adjusts timing of data transmission from the outer wireless device (AP) **10**.

First, adjustment of the timing of data transmission from the wireless device **1** will be described. FIG. **11** shows a data transmission timing of the wireless device **1**.

The upper half of the figure shows the timing of BT communication. The lower half of the figure shows the timing of WLAN communication. Reference numerals **31**A and **31**B represent data transmitted from the wireless device **2**. Reference numerals **32**A and **32**B represent data transmitted from the outer wireless device **20**. Further, reference numerals **33**A and **33**B represent data transmitted from the wireless device **1**. Reference numerals **34**A and **34**B represent data transmitted from the outer wireless device **10**. Still further, the periods represented by reference numerals **301** and **303** are communication periods in synchronous communication of BT communication. The period represented by reference numeral **302** is a non-communication period in synchronous communication of the BT communication.

If the determination result received from the status monitoring section **12** is synchronous communication, the transmission/reception control section **132** detects, as shown in FIG. **11**, the communication timing of this synchronous communication, and in synchronization with the timing, controls to perform WLAN communication during non-communication periods **302** in the synchronous communication of BT

communication. Compared with performing WLAN communication and BT communication uniformly by time division, as it is possible to effectively use periods where communication is not performed, drop in throughput can be reduced.

As described above, the transmission/reception control section **132** controls the timing of data transmission from the wireless device **1**. It also controls the timing of data transmission from the outer wireless device (AP) **10**. The timing of data transmission from the outer wireless device **10** is controlled by transmitting, to the outer wireless device **10**, a power-saving notice representing that the wireless device **1** transits into the power-saving state (sleep mode).

A power-saving function of the wireless device **1** is described. The wireless device **1** has a power-saving function for transit to a power-saving state in a case that no data is transmitted/received for a predetermined period. The outer wireless device (AP) **10** needs to recognize whether or not the wireless device **1** is in the power-saving state. Transit to or return from the power-saving state of the wireless device **1** is notified by information related to the power-saving state of the wireless device **1** included in the header of a transmission frame transmitted from the wireless device **1** to the outer wireless device **10**. Hereinafter, notice of transit to the power-saving state by this information is referred to as a power-saving notice. Notice of return from the power-saving state is referred to as a power-saving termination notice.

Upon receipt of a power-saving notice from the wireless device **1**, the outer wireless device **10** accumulates data (hereinafter, also referred to as transmission frame) to be transmitted to the wireless device **1** into a buffer or the like in the outer wireless device **10** for a permitted time. Further, the outer wireless device **10** transmits a beacon frame including information for identification with a constant cycle (approximately 100 ms). A beacon frame includes management information indicating whether the outer wireless device **10** has accumulated transmission frames of the wireless device **1**. Accordingly, the wireless device can determine presence or absence of accumulated transmission frames addressed to the device, by receiving beacon frames that are periodically transmitted. Because the transmission time of a beacon frame is shorter than the transmission time of user data, the effect of power interference caused by transmission of a beacon frame is small. Further, the above-mentioned management information and other control information included in a beacon frame are not data to be transmitted in response to a request from a user or the like.

In order that the wireless device **1** obtains a frame accumulated in the outer wireless device **10**, the wireless device **1** transmits a frame acquisition request to the outer wireless device **10**. Thus, the outer wireless device **10** is permitted to transmit an accumulated frame to the wireless device **1**, and the outer wireless device **10** transmits one accumulated frame while maintaining the power-saving state. To obtain a plurality of accumulated frames, the wireless device **1** makes a frame acquisition request plural times. If the wireless device **1** issues a power-saving termination notice to the outer wireless device **10** and then terminates the power-saving state, the outer wireless device **10** transmits all of accumulated frames. If the transmission timing of a beacon frame transmitted from the wireless device **2** with a constant cycle and the timing of synchronous communication by the wireless device **1** are overlapped with each other, the wireless device **2** may be unable to receive a beacon frame. Even when the wireless device **2** can receive no beacon frame in a certain number of times, the wireless device **2** can confirm presence or absence of accumulated frames on the outer wireless device **20**, by transmitting a frame acquisition request to the outer wireless device **20**.

Using this function, the communication control section **13** transmits a power-saving notice to the outer wireless device **10** when the wireless device **2** starts BT communication, and the wireless device **1** transmits a frame acquisition request to the outer wireless device **10** when the wireless device **1** starts WLAN communication. Otherwise, the communication control section **13** transmits a power-saving notice to the outer wireless device **10** when the wireless device **2** starts BT communication, and transmits a power-saving termination notice to the outer wireless device **10** when the wireless device **1** starts WLAN communication. As shown in FIG. **11**, in the periods **301** and **303** when the wireless device **2** performs BT communication, no data is transmitted from the outer wireless device **10**, and data is transmitted in the period **302** when the wireless device **1** performs WLAN communication. Thus, it is possible to prevent occurrence of frame loss and the like, caused by power interference due to BT communication, on transmission data from the outer wireless device **10**. Particularly, for communication of audio data, such as music and audio communication, which uses synchronous communication, the above-mentioned control method is effective because communication with a higher quality is required. As described above, by recognizing non-communication sections of synchronous communication of BT communication, it is possible to improve the mutual communication qualities during synchronous communication of BT communication.

(4) If Determination Result of Communication Status of Wireless Device **2** is Asynchronous Communication:

If the determination result of communication status of the wireless device **2** is asynchronous communication, the transmission/reception control section **132** determines a communication control method, corresponding to the communication status of the wireless device **2**, the communication status having been notified from the status monitoring section **12**, and the communication environment of the wireless device **1**. Concretely, if the determination result of the communication status of the wireless device **2**, the determination result having been notified from the status monitoring section **12**, is asynchronous communication, the transmission/reception control section **132** obtains a determination result on the communication environment of WLAN communication from the communication environment measurement section **133**. Then, the transmission/reception control section **132** determines a communication control method, depending on whether the communication environment is of a short distance or of a long distance.

First, a case where the communication environment is of a long distance is described.

If BT communication by the wireless device **2** is asynchronous communication and the communication environment of WLAN communication is of a long distance, the transmission/reception control section **132** performs control to perform BT communication by the wireless device **2** and WLAN communication by the wireless device **1** by time division. Hereinafter, the time division control is described in detail, using FIGS. **12** and **13**.

FIG. **12** shows a timing of data transmission in performing BT communication by wireless device **2** and WLAN communication by the wireless device **1** by time division. In the figure, the upper half of the figure shows the timing of communication in BT communication, and the lower half of the figure shows the timing of communication in WLAN communication. Reference numerals **35**A to **35**D represent data

transmitted from the wireless device **1**, and reference numerals **36**A and **36**B represent data transmitted from the outer wireless device **10**. Further, reference numerals **37**A to **37**C represent data transmitted from the wireless device **2**, and reference numerals **38**A to **38**C represent data transmitted from the outer wireless device **20**. Still further, the period represented by reference numeral **304** is a communicable period assigned to WLAN communication by time division, and the period represented by reference numeral **305** is a communicable period assigned to BT communication by time division.

FIG. **13** is a flowchart showing a control method for performing BT communication and WLAN communication by time division.

If the determination result of the WLAN communication environment is a short distance, the determination result having been received from the communication environment measurement section **133**, the transmission/reception control section **132** asserts the communication status signal **501** by controlling the usage status notification section **131** at a timing of t0 in FIG. **12**, and also transmits a frame including a power-saving release notice to the outer wireless device **10** (S**301**). The power-saving termination notice may be transmitted, being included in the first transmission frame **35**A in FIG. **12**. The wireless device **2** stops BT communication, and the outer wireless device **10** is enabled to transmit data. Then, WLAN communication is started between the wireless device **1** and the outer wireless device **10** (S**302**). WLAN communication is continued until a predetermined time has elapsed (S**303**). The predetermined time is the communicable time **304** that is assigned to WLAN communication under time division control, and the value of the communicable time **304** is set in a resistor in the communication control section **13** in advance. Likewise, the value of the communicable time **305** assigned to BT communication is also set in a resistor or the like. The transmission/reception control section **132** assigns the communication times of BT communication and WLAN communication by time division, with reference to the values in the resistors or the like.

The transmission/reception control section **132** controls the usage status notification section **131** at a timing t1 when the communicable time **304** has elapsed to negate the communication status signal **501**, and transmits a frame including a power-saving notice to the outer wireless device (S**304**). The power-saving notice may be transmitted, being included in the last transmission frame **35**D in FIG. **12**. Thus, the wireless device **2** is enabled to perform BT communication, and the outer wireless device **10** stops data transmission. Then, the wireless device **2** starts BT communication (S**305**). Meanwhile, the transmission/reception control section **132** measures the elapse of the communicable time **305** assigned to BT communication (S**306**). Then, the transmission/reception control section **132** controls the usage status notification section **131** at a timing of time t2 when the communicable time **305** has elapsed to assert the communication status signal **501**, and transmits a power-saving termination notice to the outer wireless device **10** (S**301**). The wireless device **2** stops BT communication, and the outer wireless device **10** becomes able to transmit data. By repeating the above-mentioned process, communications by the wireless device **1** and the wireless device **2** are performed by time division.

If data transmission from the outer wireless device **10** (data reception by the wireless device **1**) were not controlled, data may be transmitted from the outer wireless device **10** during communication by the wireless device **2**. Further, if the distance between the wireless device **1** and the outer wireless device **10** is long, frame loss easily occur because the effect of power interference becomes more significant. Accordingly, in data transmitted from the outer wireless device **10** during communication by the wireless device **2**, frame loss easily. In the present embodiment, in case that BT communication is asynchronous and the WLAN communication environment is of a long distance, data transmissions from the wireless device **1** and the wireless device **2** are performed separately by time division, and data transmission from the outer wireless device **10** is stopped during periods where the wireless device **2** is able to perform BT communication. Because interference by the mutual communications is prevented, the communication qualities can be maintained high, and occurrence of frame loss in data transmitted from the outer wireless device **10** can be reduced.

A case where the communication environment is of a short distance is described.

If BT communication by the wireless device **2** is asynchronous and the WLAN communication environment is of a short distance, the transmission/reception control section **132** performs priority control, corresponding to the communication status signal **502** and the priority signal **503** of the wireless device **2**. If the timing of BT communication by the wireless device **2** and that of WLAN communication by the wireless device **1** overlap with each other, the status monitoring section **12** determines whether or not to continue WLAN communication by wireless device **1**, corresponding to the priority signal **503**, and makes an instruction to the transmission/reception control section **132**. If the priority signal **503** is asserted (high priority), the status monitoring section **12** instructs the transmission/reception control section **132** to stop WLAN communication of the wireless device **1**. If the priority signal **503** is not asserted (low priority), the status monitoring section **12** instructs the transmission/reception control section **132** to continue WLAN communication by the wireless device **1**. Determination whether or not to continue communication may be carried out by the status monitoring section **12**, and may be carried out by the transmission/reception control section **132** having received a detection result of the communication status signal **502** and the priority signal **503** from the status monitoring section **12**.

FIG. **14** is a flowchart showing a method of communication control corresponding to the communication status and the priority of the wireless device **2**.

If the determination result of the environment of WLAN communication having received from the communication environment measurement section **133** is a short distance, the transmission/reception control section **132** first transmits a frame including a power-saving termination notice to the outer wireless device **10** (S**401**). Herein, the power-saving termination notice may be transmitted, being included in the first transmission frame similarly to FIG. **12**. Data transmission from the outer wireless device **10** is enabled. Then, based on instruction by the status monitoring section **12** as to whether or not to continue communication, the transmission/reception control section **132** controls WLAN communication (S**402**). A concrete control method in step S**402** is as follows.

FIG. **15** shows a data transmission timing in communication corresponding to the communication status and the priority of the wireless device **2**.

In the figure, after notifying the power-saving termination, the transmission/reception control section **132** controls the usage status notification section **131** at the timing of time t0 to assert the communication status signal **501**, and then starts WLAN communication. After that, when the wireless device **2** asserts the communication status signal **502** to perform BT communication at the timing of time t1 when the wireless

device **1** is performing transmission of data **401** by WLAN communication, the status monitoring section **12** of the wireless device **1** detects the communication status signal **502** and determines the priority signal **503**. Because the priority signal **503** is not asserted at that time, the status monitoring section **12** instructs the transmission/reception control section **132** to continue WLAN communication. Upon receiving the instruction, the transmission/reception control section **132** continues to perform WLAN communication, and maintains the communication status signal **501** of the wireless device **1** asserted. Because the communication status signal **501** is not negated, the wireless device **2**, after a certain time has elapsed, negates the communication status signal **502** once, the communication status signal **502** having been asserted as described above, and does not perform BT communication. After that, when the data transmission by the wireless device **1** is terminated at time t2 and the communication status signal **501** of the wireless device **1** is negated, the wireless device **2** again asserts the communication status signal **502**, and starts transmitting data **402** by BT communication. Then, when the wireless device **2** has terminated communication at time t3, the wireless device **2** negates the communication status signal **502**. Further, during the period from time t2 to time t3 when the wireless device **2** is performing communication, as the outer wireless device **10** is permitted to transmit data by the above-mentioned power-saving termination notice, the outer wireless device **10** transmits data **403** and **404** to the wireless device **1**.

After that, the wireless device **1** again starts WLAN communication at time t4, and transmits data **405**. Then, at time t5 during transmission of the data **405**, when the wireless device **2** asserts the communication status signal **502** to perform communication and asserts the priority signal **503** to make a request for BT communication, the status monitoring section **12** of the wireless device **1** detects the communication status signal **502** and determines the priority signal **503**. Because the priority signal **503** is asserted at that time, the status monitoring section **12** instructs the transmission/reception control section **132** to stop data transmission. On receiving the instruction, the communication control section **13** stops data transmission, and negates the communication status signal **501**. Thus, BT communication by the wireless device **2** is started, and data **406** is transmitted. Although the priority signal **503** is issued together with the communication status signal **502**, the ratio of issuance is set in advance in a resistor or the like in the communication control section **13**, and the transmission/reception control section **132** has the priority signal **503** issued corresponding to the setting.

After that, when BT communication by the wireless device **2** ends at time t6 and the communication status signal **502** and the priority signal **503** of the wireless device **2** are negated, the transmission/reception control section **132** asserts the communication status signal **501** to transmit data **407**. Through the above-mentioned process, priority control is performed, corresponding to the communication status and the priority of the wireless device **2**.

If the distance between the wireless device **1** and the outer wireless device **10** is short, because the attenuation of the transmission/reception power in WLAN communication is comparatively small, the effect of power interference is small, if any, and the possibility of occurrence of frame loss is low. In this situation, in the present embodiment, in case that BT communication is asynchronous communication and the WLAN communication environment is of a short distance, data transmission from the outer wireless device **10** is not stopped even during a period where the wireless device **2** is performing BT communication. Compared with stopping data transmission from the outer wireless device **10** during BT communication, drop in throughput can be reduced. Further, as the wireless device **1** and the wireless device **2** adjust the timing of own communications, corresponding to the mutual communication statuses, drop in throughput can be reduced, compared with performing communications by time division.

As described above, by the wireless communication terminal **100** in the present embodiment, the wireless device **1** that performs WLAN communication recognizes the communication status by analyzing a pattern of the communication status signal **502** of BT communication by the wireless device **2**, and based on it, the wireless device **1** performs communication control of WLAN communication and BT communication. Thus, it is possible to reduce occurrence of frame loss due to power interference, and reduce drop in throughput, compared with a method that performs communication control uniformly by time division. Further, when it was assumed that communication control is performed with a priority signal, when contention between timings of frame transmission of BT communication and WLAN communication occurs, WLAN communication may be stopped by the priority signal of the wireless device **2** and frame loss may thereby occur. As in the present embodiment, by performing WLAN communication in non-communication periods **302** instead of performing equal control with a priority signal, frame loss due to issuance of a priority signal does not occur in WLAN communication. Further, according to the present embodiment, not only data transmission from the wireless communication terminal **100** but also data transmission from the outer wireless device **10** are controlled, and then communication quality can be maintained higher. Further, because control of data transmission from the outer wireless device **10** is performed using the power-saving function of the wireless device **1**, if WLAN communication is performed by a wireless system in conformity with IEEE 802.11 standard, an existing protocol can be used, without the necessity of preparing a new protocol for transmission control of the outer wireless device **10**.

The present invention developed by the inventors has been concretely described, based on embodiments. The invention is not limited to itself. It is needless to say that various changes and modifications are possible without departing from the invention.

In the present embodiment, the description has been made, taking an example of a wireless communication terminal that performs wireless communication in conformity with IEEE 802.11 standard and wireless communication in conformity with Bluetooth standard. Without being limited itself, the invention can be also applied to a wireless communication terminal that performs wireless communication in conformity with other standards.

Further, in the time division control, shown in FIG. **12**, instead of fixing the communicable times **304** and **305** assigned to BT communication and WLAN communication, it is also possible to dynamically change the communicable times. When the wireless device **2** performs streaming communication, such as music, with a high communication frequency, communication quality can be improved by making the communicable time **305** of the wireless device **2** long.

For the wireless communication terminal **100** in the present embodiment, a case of connecting the wireless device **1** and the wireless device **2** with three lines (**501**, **502**, and **503**) has been shown as an example. Without being limited to the connection, arrangement by connection with two lines of the mutual communication status signals **501** and **502**, as shown in FIG. **2**, may be made. In this case, in the control shown in FIG. **15**, the status monitoring section **12** does not

determine the priority signal **503**, but determines whether or not to continue communication, based on the communication status signal **502**.

What is claimed is:

1. A method of wireless communication, comprising the steps of:

a) generating a communication status signal in a predetermined period of time which is set to a first value while a first wireless communication is operating and set to a second value while the first wireless communication is not operating in the predetermined period of time;

b) analyzing the communication status signal;

c) enabling a second wireless communication that is different from the first wireless communication when the communication status signal is not set to the first value in the predetermined period of time;

d) suspending the second wireless communication when a total time of the communication status signal set to the first value reaches or exceeds a predetermined value in the predetermined period of time;

e) when the communication status signal does not reach the predetermined value in the predetermined period of time and the communication status signal is cyclic, enabling a second wireless communication while the level of the communication status signal is the second value.

2. The method of wireless communication according to claim **1**, further comprising the step of:

f) when the communication status signal does not reach the predetermined value in the predetermined period of time and the communication status signal is not cyclic, enabling the second wireless communication based on a signal intensity of at least one of the second wireless communication and the first wireless communication.

3. The method of wireless communication according to claim **1**, further comprising the step of:

f) when the communication status signal does not reach the predetermined value in the predetermined period of time and the communication status signal is not cyclic, enabling the first wireless communication or the second wireless communication depending on a value of a priority signal.

4. The method of wireless communication according to claim **1**, wherein the first wireless communication is in a 2.4 GHz band.

5. The method of wireless communication according to claim **1**, wherein the second wireless communication is in a 2.4 GHz band.

6. A method of wireless communication, comprising the steps of:

a) generating a communication status signal in a predetermined period of time which is set to a first value while first wireless communication is operating and set to a second value while the first wireless communication is not operating in the predetermined period of time;

b) analyzing the communication status signal;

c) enabling a wireless LAN communication that is different from the first wireless communication when the communication status signal is not set to the first value in the predetermined period of time;

d) suspending the wireless LAN communication when a total time of the communication status signal set to the first value reaches or exceeds a predetermined value in the predetermined period of time;

e) when the communication status signal does not reach the predetermined value in the predetermined period of time and the communication status signal is cyclic, enabling a wireless LAN communication while the level of the communication status signal is the second value,

wherein the first wireless communication complies with an IEEE 802.15 standard.

7. The method of wireless communication according to claim **6**, further comprising the step of:

f) when the communication status signal does not reach the predetermined value in the predetermined period of time and the communication status signal is not cyclic, enabling the wireless LAN communication based on a signal intensity of at least one of the wireless LAN communication and the first wireless communication.

8. The method of wireless communication according to claim **6**, further comprising the step of:

f) when the communication status signal does not reach the predetermined value in the predetermined period of time and the communication status signal is not cyclic, enabling the first wireless communication or the wireless LAN communication depending on a value of a priority signal.

9. The method of wireless communication according to claim **6**, wherein the first wireless communication is in a 2.4 GHz band.

10. The method of wireless communication according to claim **6**, wherein the wireless LAN communication is in a 2.4 GHz band.

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